

## Possible Procedure Modification and a System Likeness for Object Identifying on Remote Sensing Images

**Fedulov Y., Kuleshov A., Murashko N., Romanchik D.**

United Institute of Informatics Problems,  
National Academy of Sciences of Belarus, Minsk  
BELARUS

### ABSTRACT

Modified grey-scale image objects classification on the basis of variance analysis of their vectorial models is suggested. After calculating the generalized, the intergroup and the average of particular dispersions the variance ratio of vectorial models of analyzing objects is computed and classification on the basis of threshold values of their similarity is made. Experimental classification data are cited.

### INTRODUCTION

Similarity measure is one of the important instruments of data analysis in matching, classification, similarity evaluation and correlation of analyzing objects [1]. Wide application of the correlation coefficient as a measure of similarity of analyzing objects becomes above all clear due to its stability as an image recognition characteristic both under gross and small volume of sampling [2]. It should be stated that the correlation coefficient is near true as few as there is a gross number of independent observations subject to the same near-normal distribution. In cases with limited number of experimental data and their non-linearity it is recommended [2] to use correlation ratio (CR) –  $\eta$ .

$$\eta = \sqrt{\frac{\bar{\delta}_i^2}{\sigma^2}}, \quad (1)$$

where  $\bar{\delta}_i^2$  - intergroup (intragroup) dispersion;  $\sigma^2$  - generalized dispersion.

### 1. CORRELATION RATIO MODIFICATION

Weights of vectors of the tracing contour described similarly the chain code (table 1) would be used as invariant information features.

Table 1

Normalized vectorial models of analyzing objects

Object number	Vector weights	Rotation angle, $\alpha$
1	2,2,1,2,4,5,6,5,5,5,7,8,8 (13)	0°
2	2,1,2,2,4,5,6,5,5,5,7,8,8 (13)	0°
3	2,2,1,2,4,5,5,6,5,5,7,8,8 (13)	0°

Weights of vectors of the object #1 used as etalon features are labeled as  $A_1$ . Features of analyzing objects #2 and #3 (table 1) are correspondingly labeled as  $B_2[i]$  and  $B_3[i]$ . Visualization of 3 object contours and superimposed image of these synthesized objects are shown on fig 3.

Fedulov, Y.; Kuleshov, A.; Murashko, N.; Romanchik, D. (2005) Possible Procedure Modification and a System Likeness for Object Identifying on Remote Sensing Images. In *Emerging EO Phenomenology* (pp. 10-1 – 10-8). Meeting Proceedings RTO-MP-SET-094, Paper 10. Neuilly-sur-Seine, France: RTO. Available from: <http://www.rto.nato.int/abstracts.asp>.

Report Documentation Page			Form Approved OMB No. 0704-0188					
<p>Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p>								
1. REPORT DATE <b>01 OCT 2005</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>						
<b>4. TITLE AND SUBTITLE</b> <b>Possible Procedure Modification and a System Likeness for Object Identifying on Remote Sensing Images</b>			5a. CONTRACT NUMBER					
			5b. GRANT NUMBER					
			5c. PROGRAM ELEMENT NUMBER					
<b>6. AUTHOR(S)</b>			5d. PROJECT NUMBER					
			5e. TASK NUMBER					
			5f. WORK UNIT NUMBER					
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> <b>United Institute of Informatics Problems, National Academy of Sciences of Belarus, Minsk BELARUS</b>			8. PERFORMING ORGANIZATION REPORT NUMBER					
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>			10. SPONSOR/MONITOR'S ACRONYM(S)					
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)					
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b> <b>Approved for public release, distribution unlimited</b>								
<b>13. SUPPLEMENTARY NOTES</b> <b>See also ADM202114, RTO-MP-SET-094. Emerging EO Phenomenology (Naissance de la phenomenologie et de la technologie electro-optique)., The original document contains color images.</b>								
<b>14. ABSTRACT</b>								
<b>15. SUBJECT TERMS</b>								
<b>16. SECURITY CLASSIFICATION OF:</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33.33%; padding: 2px;">a. REPORT <b>unclassified</b></td> <td style="width: 33.33%; padding: 2px;">b. ABSTRACT <b>unclassified</b></td> <td style="width: 33.33%; padding: 2px;">c. THIS PAGE <b>unclassified</b></td> </tr> </table>			a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	<b>17. LIMITATION OF ABSTRACT</b> <b>UU</b>	<b>18. NUMBER OF PAGES</b> <b>8</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>						

**Possible Procedure Modification and a System  
Likeness for Object Identifying on Remote Sensing Images**

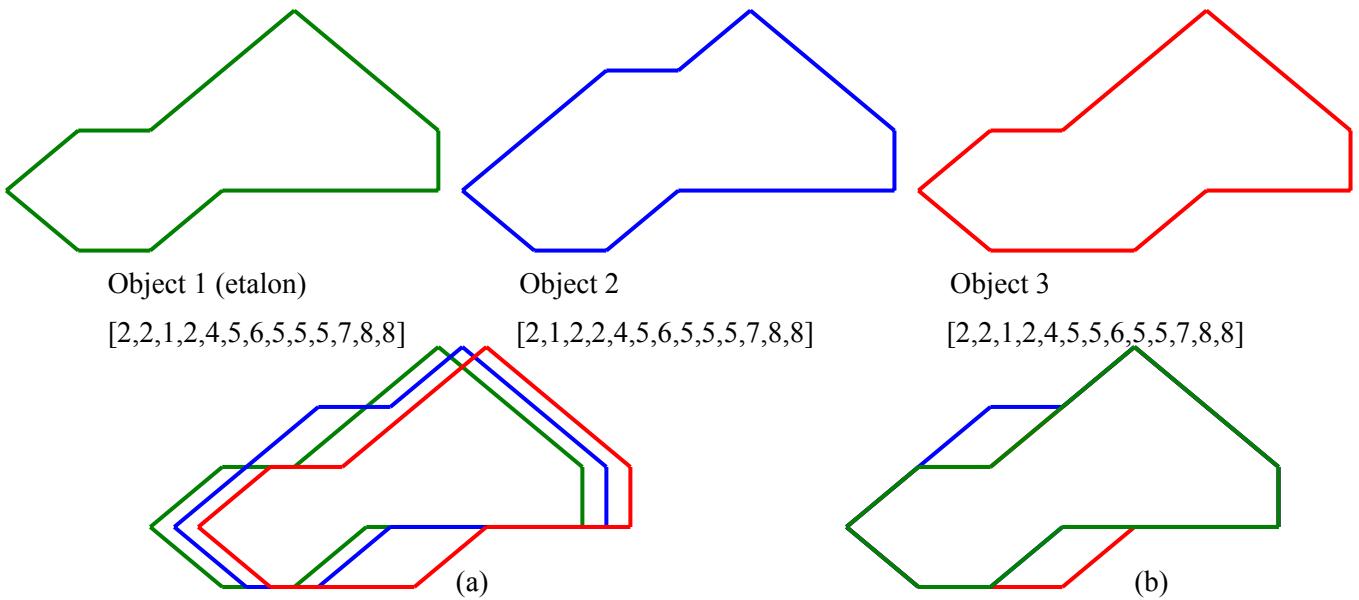


Fig.1. Sub-superimposed (a) and superimposed (b) image of 3 synthesized objects

The average of particular dispersions [3] for objects #2 and #3 is correspondingly

$$\bar{\sigma}^2_{A(B_2)} = \frac{\sum (A[i] - B_2[i])^2}{n} = \frac{2}{13} = 0,15384615;$$

$$\bar{\sigma}^2_{A(B_3)} = \frac{\sum (A[i] - B_3[i])^2}{n} = \frac{2}{13} = 0,15384615.$$

Generalized dispersion

$$\sigma_A^2 = \frac{\sum A_i^2}{n} - \bar{A}^2 = \frac{342}{13} - \frac{60}{13} = 5,00591716.$$

Intergroup dispersion for objects #2 and #3

$$\bar{\delta}_{B_2}^2 = \left| \sigma_A^2 - \bar{\sigma}^2_{A(B_2)} \right| = 4,85207101; \quad \bar{\delta}_{B_3}^2 = \left| \sigma_A^2 - \bar{\sigma}^2_{A(B_3)} \right| = 4,85207101.$$

Correlation ratio

$$\eta_{(A, B_2)} = \sqrt{\frac{\bar{\delta}_{B_2}^2}{\sigma_A^2}} = \sqrt{\frac{4,85207101}{5,00591716}} = 0,98451366;$$

$$\eta_{(A, B_3)} = \sqrt{\frac{\bar{\delta}_{B_3}^2}{\sigma_A^2}} = \sqrt{\frac{4,85207101}{5,00591716}} = 0,98451366.$$

Calculated CR of analyzing objects  $B_2$  and  $B_3$  relative to CR of the etalon are equal although descriptions of their contour representation are different (table 1). Analysis of vector weights and experiments to qualify correlation ratio have shown [5, 6] that it is necessary to inset ranking of differential values  $(A[i] - B_l[i])k$ . Insertion of k-coefficient for differential values ranking of vectors is the **first modification** of the utilized correlation ratio [6, 9]. Differential values ranking could be made using the following mathematical equations:

$$k_1 = \sqrt{\frac{i(A[i] + B_l[i])}{n(S_1 + S_l)}} \quad (2); \quad k_2 = \sqrt{\frac{i}{n} \left( \frac{A[i]}{S_1} + \frac{B_l[i]}{S_l} \right)} \quad (3); \quad k_3 = \sqrt{\frac{i}{n}} \quad (4),$$

where  $i$  – running number of the analyzing object vector whose differential weight is other than zero;

$n$  – number of vectors of etalon or the analyzing object (the most of them is chosen);

$S_1$  – sum of weights of vectors of the etalon;

$S_i$  – sum of weights of vectors of analyzing object ( $i$ ).

**Second modification of CR** is bound up with the requirement fulfillment about the similarity measure symmetry [2]  $\eta_{(A,B)} = \eta_{(B,A)}$ . Modified CR (MCR) meeting mathematical requirements of similarity measure [2] is given by the following [5]:

$$\eta_M = \sqrt{\frac{\bar{\delta}_{R_i}^2}{\sigma_{R_i}^2}}, \quad (5)$$

where  $\sigma_{R_i}^2 = \sigma_A^2 + \sigma_{B_i}^2$  – sum of generalized dispersion of the etalon (A) and the analyzing object ( $B_i$ );

$\bar{\delta}_{R_i}^2 = \bar{\delta}_A^2 + \bar{\delta}_{B_i}^2$  – sum of intergroup dispersion of the etalon (A) and the analyzing object ( $B_i$ ).

Experiments gave preferences to the ranking coefficient selection and the add-on of lacking direction vectors up to the equinumerous set of features by mathematical expectation meanings of their vectorial models:

$$\eta_{(A,B_2)} = \eta_{(B_2,A)} = 0,99437419; \eta_{(A,B_3)} = \eta_{(B_3,A)} = 0,99209212.$$

## 2. VARIANCE RATIO FORMATION OF VECTORIAL MODELS OF ANALYZING OBJECTS.

On a basis of MCR utilized as a similarity measure of analyzing objects boundary representation on grey-scale images, we'll consider the following variance ratios:

- intergroup and generalized dispersions (5) – correlation ratio;
- generalized dispersion to the sum of the generalized and the average of particular dispersions

$$\eta_2 = \sqrt{\frac{\sigma_{R_i}^2}{\sigma_{R_i}^2 + \bar{\sigma}_i^2}}; \quad (6)$$

- intergroup dispersion to the sum of the generalized and the average of particular dispersions

$$\eta_3 = \sqrt{\frac{\bar{\delta}_{R_i}^2}{\sigma_{R_i}^2 + \bar{\sigma}_i^2}}, \quad (7)$$

aimed for evaluation of a similarity measure and subsequent objects classification.

## 3. EXPERIMENTAL VERIFICATION OF AN EQUINUMEROUS SET OF FEATURES FOR OBJECTS CLASSIFICATION.

To process a grey-scale remote sensing space image on a computer it is necessary to digitize it. A digital image of certain locality is depicted on the figure 2. Optical density (image density) value and its outside configuration (geometry) characterize a grey-scale image of the locality. A contour carries the maximal

information about an object image and significantly enables to decrease the computer input of information content during selective inputting but particularly affected to brightness and geometric distortions. In this context utilization of optimum intervals of brightness threshold values and local anisotropic filtration of search zones of the nearest point enables to get more higher boundary representation of grey-scale image objects and forms its vectorial model in a boundary tracking process.

The digital image after its filtration and boundary extraction utilizing the concurrent activities in displacement and summation during the image convolution with mask transform [5] is depicted on the Figure 3. In process of boundary extraction the vectorial models of boundary representation of analyzing object are formed.



Fig. 2 Digital image of the locality



Fig. 3 Digital image processing effect

To increase accuracy and trustworthiness of contour's readout on grey-scale object images in the United Institute of Informatics Problems, Belarus it was developed a system providing automatic selective readout and boundary representation [8]. The subsystem for boundary representation (Fig. 4) contains Scanner (S), Photoelectric converter (PhC), Analog-digital conversion unit (ADCU), Memory unit (MU), Boundary points selection unit (BPSU), Control unit (CU) Searching scan unit (SCU), Graphics tracking unit (GTU), Threshold value formation unit (TVFU) and Commutator (C)

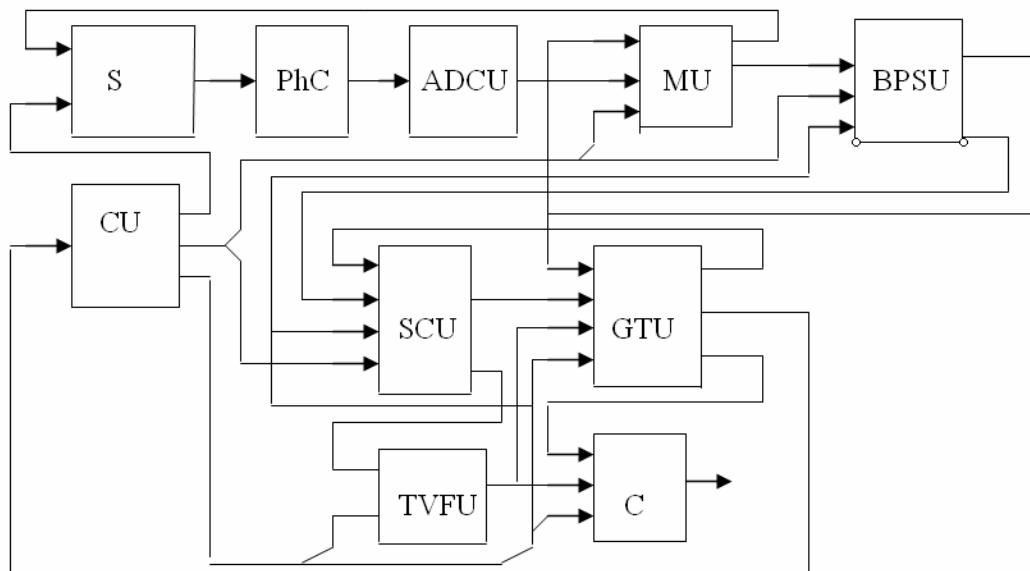


Fig.4 Block diagram of object edge recognition subsystem on remote sensing images

Normalization of analyzing objects vectorial models by scale and orientation [6] enables to form invariant information features. Normalized vectorial models of 7 analyzing objects, first of which was set for the etalon are located in table 2.

Adding the lacking vectors weights up to the equinumerous set of features by mathematical expectation meanings and using the ranking coefficient we compute variance ratios (5) and (6) for the locality situated analyzing objects by the worked out software module TK07, and classify them by threshold values of similarity measure [7].

Table 2  
Normalized vectorial model of initial image objects

No	Vectors weights {number of vectors}	Rotation angle, $\alpha$
1	1,1,1,1,3,3,3,3,3,5,3,3,3,5,5,5,5,7,5,7,7,1,7,7,7,1,7 {28}	0°
2	1,1,1,3,3,3,3,3,3,3,3,3,5,5,5,5,5,5,7,7,7,7,7,7,1,7,7 {30}	0°
3	1,1,3,3,1,1,1,3,3,3,5,5,5,5,3,5,5,7,7,5,7,1,7,7,1,7 {28}	180°
4	1,1,1,1,1,1,1,3,3,3,3,3,5,5,3,5,5,5,5,5,5,7,7,7,7,7,1,7 {30}	0°
5	1,1,1,3,1,1,1,1,3,3,3,5,5,5,5,5,5,5,7,7,7,1,7 {24}	0°
6	1,1,1,1,3,1,3,3,1,3,3,3,3,5,3,3,5,3,5,5,7,5,5,5,7,5,7,5,5,7,1,7,7,7,1,7 {42}	0°
7	1,1,1,3,1,1,1,3,3,3,3,3,3,5,3,5,5,5,5,5,7,7,7,5,5,7,7,7,7,7,1,1,7 {34}	270°

Results of a similarity measure computing for analyzing objects using variance ratios (5) – (7), the ranking coefficient and an add-on of lacking direction vectors weights of the etalon or the analyzing object by mathematical expectation meanings are located in the Table 3. It should be stated that ranking of analyzing objects (table 3) in decreasing order of their variance ratios has the same distribution for utilized variance ratios (5)-(7).

Table 3  
Computation of variance ratios value

Object number	$\eta_M$	$\eta_2$	$\eta_3$
1	1,00000000	1,00000000	1,00000000
2	0,89260599	0,91168540	0,81373810
3	0,90017516	0,91681997	0,82529857
4	0,82261843	0,86930268	0,71510441
5	0,90868641	0,92281044	0,83854531
6	0,84103261	0,87954314	0,73972447
7	0,83581908	0,87658396	0,73266559
$\sum \Delta \eta_i / n$	0,11415176	0,08903634	0,19070336

It follows from the Table 3 that variance ratio values (7) have the smallest similarity measures for analyzing objects relative to values computed with equations (5) and (6). Hence the variance ratio (7)  $\sum \Delta \eta_3 / n = 0,19070336$  is more sensitive to the similarity measure of analyzing objects relative to distinguishing [observable] features of direction vectors weights in the capacity of their boundary representation.

Boundary representations of 7 analyzing objects with their variance ratios are depicted on the Figure 5.

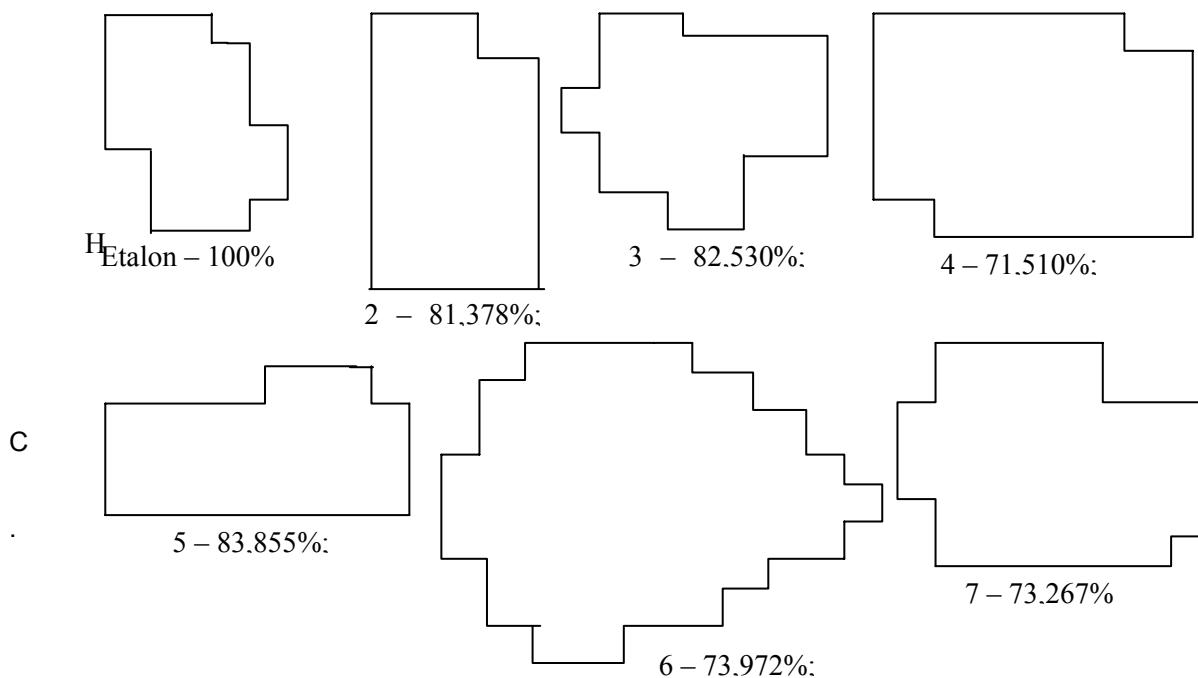


Fig. 5 Boundary representations of analyzing objects with their variance ratios

Classification results of analyzing objects by threshold values of their variance ratio are located in the table 4.

 Table 4  
Analyzing objects classification

Object numbers	MCR, %	Object's cluster number	Cluster number	Thresholds Similarity measures
1	100,00	1	1	99,953 – 100,000
2	81,373	10	2	99,730 – 99,952
3	82,530	10	3	99,400 – 99,729
4	71,510	11	4	98,760 – 99,399
5	83,855	9	5	97,560 – 98,759
6	73,972	11	6	95,450 – 97,559
7	73,267	11	7	92,810 – 95,449
	-	-	8	89,040 – 92,809
	-	-	9	83,850 – 89,039
	-	-	10	76,990 – 83,849
	-	-	11	68,270 – 76,989
	-	-	12	57,630 – 68,269
	-	-	13	45,750 – 57,629
	-	-	14	31,080 – 45,749
	-	-	15	15,850 – 31,079
	-	-	16	0,800 – 15,849

System likeness for object identifying on remote sensing images is shown on the fig. 6.

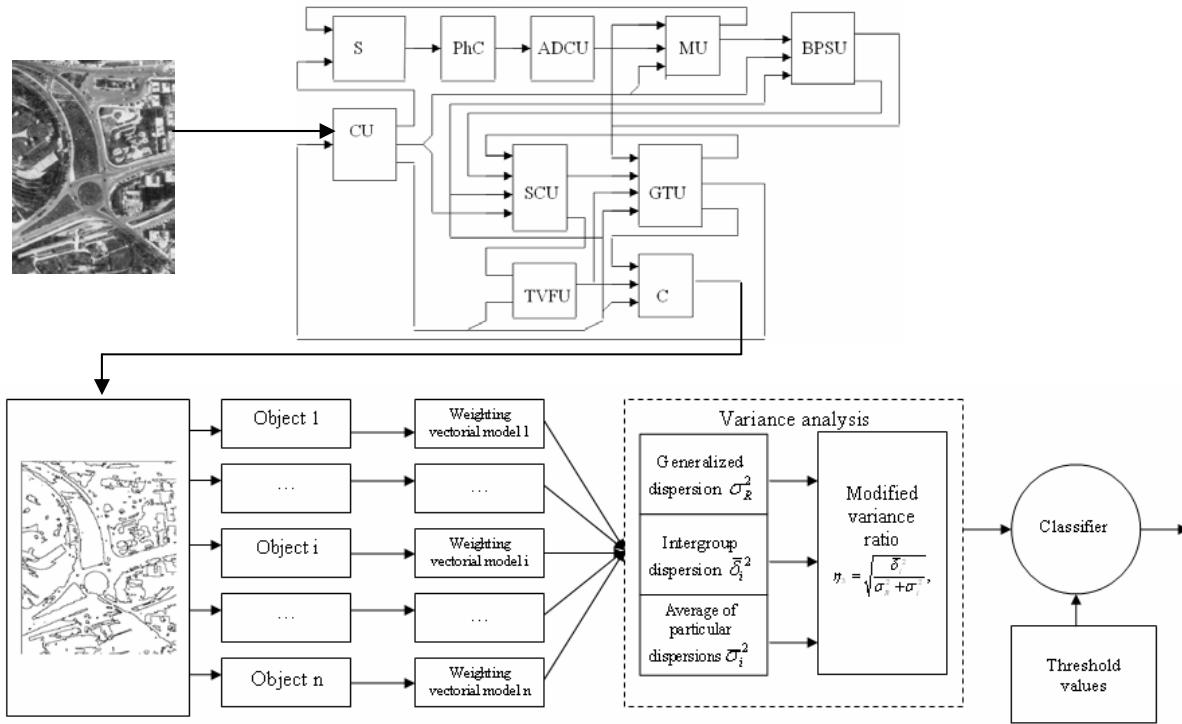


Fig. 6. Object identifying system likeness

## CONCLUSION

The sensitivity of variance ratio computing is increasing up to 5,74% relative to utilized variance ratio (5) by forming and using of equinumerous set of features (adding direction vectors weights by mathematical expectation and computing the ranking coefficient of difference between etalon vector weight and analyzing object vector weight) for classification of analyzing objects on remote sensing images by their boundary representation with the aid of variance ratio (7) of their vectorial models.

## REFERENCE

- [1] G.V.Raushebakh. Measure of Adjacency and Similarity // Analysis of Non-numerical Information in Social Case Studies. Moscow: Naukha (Science), 1985. – pp 169-203.
- [2] Applied Statistics. Classification and Dimension Reduction. Book of Reference. S.A. Ajvazjan, K.M.Bukhshtaber, I.S. Enjukov, L.D.Meshalkin / Edited by S.A. Ajvazjan. - Moscow: Finansy and Statistika (Finance & Statistics), 1989.
- [3] Venetsky I.G., Kildishev G.S. Theory of Probability and Mathematical Statistics. - Moscow: Statistika (Statistics), 1968.
- [4] Lapa V.G. Mathematical Fundamentals of Cybernetics. – Kiev: Vysshaya Shkola (The Higher School), 1971.
- [5] Identification of Contour Objects on Remote Sensing Images / Ablameyko S.V., Borichev S.P. Kruchkov A.N., Kuleshov A.Y. // 1-st Byelorussian Space Congress: Materials of the Congress 28-30 October, 2003. – Minsk: UIIP NAS of Belarus, 2003. – pp 143-145.
- [6] Kuleshov A.Y., Romanchik D.V. Classification of Scale-grey Images in the Absence thereof Learning Samples // Digital Image Analysis: Collected articles / Edited by S.V.Ablameyko – Minsk: UIIP NAS of Belarus, 2002. – pp 59-68.
- [7] Ablameyko S.V., Kuleshov A.Y. Definition of Contour Objects Similarity Measure, approximated by Circular Arcs // Pattern Recognition and Image Analysis: Paper theses of the 2-nd All-Russian Conference attended by CIS scientists. – Moscow, 1995. – part 2. – pp 53-56.
- [8] USSR Certificate of Authorship #1785014 (G06 K 9/00). Extraction System for Contour Object Images / V.K.Erokhovets, M.A.Samoshkin, A.Y.Kuleshov (USSR). - № 4873043/24; Rights claimed on 30.08.90; Published 30.12.92, Bulletin № 48 // Discoveries. Patents. – 1992. - № 48. – p. 166.
- [9] Kuleshov A.Y., Formation of Characteristics for Object Identification on Remote Sensing Images Using Correlation Ratio // Information Processing and Control in Emergencies and Extremis. Proceeding of the 4<sup>th</sup> international conference 29 November – 1 December 2004. Minsk: UIIP NAS of Belarus, 2004. pp 152-157.